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GRAIN QUALITY OF MAIZE INBRED LINES ORIGINATED FROM LOCAL POPULATIONS

KVALITET ZRNA SAMOOPLODNIH LINIJA KUKURUZA DOBIJENIH OD LOKALNIH POPULACIJA

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ABSTRACT

Evaluation of seed quality was done from seeds of inbred lines originated from local maize populations of Eastern Serbia. Following parameters were investigated: 1000 seed weight, dry matter content, protein content and lysine content. In this study, 1000 seeds weight ranged from 311.03 to 365.04 g. In dry matter content were included soluble carbohydrates, starch, ash, and the remainder of proteins. It ranged from 10.14 to 10.96 %. The protein content is ranged from 9,31 to 10,84 %, but the crude protein content is not necessarily an indicator of quality. Important quality indicator is the amount of the essential amino acids and their digestibility. Several lines were obtained a lysine content up to 3 %, which is considered to be the high content of lysine in the "normal" maize types. The results indicated that the local maize populations can be a significant source of beneficial genes to obtain better quality hybrids.

***Key words**: maize, inbred lines, seed quality, organic production.*

REZIME

Zbog visoke produktivnosti, kao i visoke adaptabilnosti, kukuruz je postao veoma raširena kultura i gaji se u različitim klimatskim uslovima. Današnji hibridi daju znatno veće prinose od ranije gajenih sorti i hibrida, što je rezultat dugogodišnjeg oplemenjivačkog procesa. Semenarske kompanije diktiraju programe oplemenjivanja gde je glavni cilj prvenstveno prinos, dok je hranljivi kvalitet dobijenih hibrida uglavnom zapostavljen.

U eri najveće tehnološke razvijenosti otkad postoji ljudska civilizacija, sve je veća potreba za proizvodnjom zdravstveno bezbedne hrane. Zbog toga organska poljoprivreda zauzima sve značajnije mesto u agrarnoj politici razvijenih zemalja. S obzirom da su izvori varijabilnosti za stvaranje novih hibrida kukuruza gotovo iscrpljeni, javlja se trend povratka starim, gotovo zaboravljenim, sortama kukuruza koje mogu biti značajan izvor kvalitetne hrane za ljude. Lokalne sorte - populacije kukuruza mogu dati značajan doprinos poboljšanju kvaliteta ishrane kako ljudi, tako i životinja.

U ovom istraživanju je korišćeno 15 samooplodnih linija kukuruza koje su dobijene iz lokalnih populacija poreklom iz istočne Srbije (okolina Zaječara i Pirota). Ogled je postavljen po slučajnom blok sistemu u tri ponavljanja. Određivani su sledeći parametri: masa 1000 semena, sadržaj suve materije, sadržaj sirovih proteina i sadržaj lizina.Masa 1000 semena je iznosila od 311,3 do 365,04 g. U sadržaj suve materije ulaze rastvorljivi ugljeni hidrati, skrob, pepeo, proteini i ostatak. Sadržaj suve materije je iznosio od 10,14 do 10,96%. U ovom istraživanju je dobijen sadržaj proteina od 9,31 do 10,84%. Ovo svojstvo je pod jakim uticajem genetičkih faktora, međutim, sadržaj sirovih proteina nije nužno i pokazatelj kvaliteta. Kvalitet proteina biljaka se ceni i prema količini esencijalnih aminokiselina i njihovoj svarljivosti. Kukuruz, prema sadržaju esencijalnih aminokiselina, ne spada u kvalitetna hraniva. U semenu standardnih tipova kukuruza lizin nije sadržan u većoj meri, što umanjuje njihovu nutritivnu vrednost. Navode se rezultati sadržaja lizina u zrnu kukuruza normalnog tipa od 1,6%, a u zrnu opaque-2 tipa 3,7%. U ovom radu, kod pojedinih linija je dobijen sadržaj lizina preko 3%, što se smatra za visok sadržaj lizina kod „običnih" tipova kukuruza. Dobijeni rezultati ukazuju da lokalne populacije mogu biti značajan izvor poželjnih gena za dobijanje kvalitetnijih hibrida kukuruza.

***Ključne reči**: kukuruz, samooplodne linije, kvalitet zrna, organska proizvodnja.*

INTRODUCTION

Due to the high productivity and high adaptability, maize has become widespread culture and grown in different climates. Today's single-cross hybrids provide significantly higher yields than earlier double-cross and open pollinated varieties, as a result of long-term breeding process. Seed companies dictate breeding programs, where the main objective is yield, and nutritional quality of the obtained hybrids is less significant.

According to the content of protein, maize is one of the poor feed. Earlier, an attempt was made to improve the quality of the maize genetically engineered. Mutants opaque-2 (with a high content of lysine) and floury-2 (with a high content of tryptophan), did not give the expected results. Due to the adverse effects of the correlation (lower yield, a softer grain, increased moisture in the grain, weakened stalks and other product characteristics); this program was abandoned after 20 years (*Vasal, 2001*).

Given that the sources of variability for creation of new hybrids almost exhausted (*Hallauer, 1994)*, there is a trend back to the old, almost forgotten varieties of corn that can be a significant source of high-quality food for humans (*Pollak and Salhuana 2001*). *Borlaug (1992*) started with the introduction of the genetic diversity of wild plants and local populations in modern varieties of plants.

In the era of the greatest technological development of human civilization, there is a growing need for the production of safe food. Generations of people have grown up in an industrial food, with ample use of artificially synthesized substances. After decades of use industrial food, organizations and movements for the obtaining food in a natural way are getting louder. Organic farming, also, makes a significant contribution in increasing

interest in the development of hybrids with higher grain quality. Maize is poor in some essential amino acids, and lysine is one of them *(Bhan et al, 2003)*.

In this paper, we studied 15 inbred lines with high protein content, in order to detect lines with higher lysine content than conventional hybrids.

MATERIAL AND METHOD

The field experiment was performed on the experimental field of the Institute for agricultural and technological research in Zaječar during 2003 and 2004. The area where the institute is located has characteristics of temperate continental climate (Table 1).

In order to obtain the seeds of the same generation of self-crossing (S_4) in both years of investigation, harvested seed from 2002 was used for planting.

From each line, sample of 15 ears was taken. From each ear the same number of grains was counted. In this way it is made unique pattern for every inbred line, for each replication. That balanced sample has been used for investigation of all the properties.

Table 1. Average monhtly temperatures (^oC) and precipitations (mm) for the April-September in 2003 and 2004 and long-term averages for period 1967-2002

Month	Temperatures (^oC)			Precipitations (mm)		
	2003	2004	1967-2002	2003	2004	1967-2002
April	10.2	11.9	11.2	89.0	46.4	52.8
May	22.9	14.9	16.4	60.5	27.6	65.6
June	22.5	19.5	19.6	43.3	81.3	68.1
July	22.3	21.9	21.5	55.6	49.0	57.9
August	24.3	20.5	20.9	1.3	62.1	38.2
September	15.6	15.9	16.3	67.6	35.6	45.5
Average	19.6	17.4	17.7	317.3	302.0	327.3

1000 seed weight was measured on a random sample of absolutely pure and air-dry seed. The dry matter content was calculated by subtracting % hygroscopic moisture of 100 (*Sl. List br. 47/87*).

Crude protein was computed indirectly by the standard Kjeldahl method *(Vivek et al., 2008)*, based on nitrogen multiplied by factor 6.25 (conversion factor for maize). Lysine content in seeds was determined from hydrolysate, on the device UPLC AMINO ACID ANALYSIS SOLUTION in the laboratory "Hemtek" in Belgrade.

For each feature, one-way analysis of variance (ANOVA) was used to examine differences in mean values among lines. Differences were considered as significant at probability value $p<0.01$. Statistical analyses were performed using the program *STATISTICA 8.0.*

RESULTS AND DISCUSSION

Process of obtaining inbred lines sometimes required more than ten years, with the uncertain results. After five years of work on obtaining inbred lines we made an assessment and evaluating the quality of grain. This allows working only with those lines that match the specified properties. Results of mean values and LSD test at $p<0.01$ for each analyzed inbred line are presented in Table 2 and Table 3. By observing the results, we can notice, that there were statistically significant differences between the analyzed inbred lines. 1000 seed weight is the ratio between the weight and number of seeds and represents seed size. It is also one of the main yield components of corn. This property is very variable because it is affected by genetic factors and environmental conditions. The average weight of 1000 seeds ranged from 311.03 (inbred line No. 4 in 2003) to 365.04 g (Inbred line No. 11 in 2004; Table 2). The obtained values are in agreement with the results of researchers who have examined this feature in hybrids (*Bekrić, 1997*).

In the grain of standard hybrids, dry matter content is about 10 % (*Bekrić (1997)*. In this study dry matter content of inbred lines ranged from 10.14 (inbred line No. 2 in 2003) to 10.96 % (inbred line No. 5 in 2004; Tab. 2).

Seed protein content is strongly influenced by genetic factors. A number of authors refer that the protein content of the standard hybrids varies from 5-12 %. Results of the protein content in standard hybrids were from 8.3 to 12.3 % (*Radosavljevic et al. 2010*). Results of the grain protein content of tropical maize inbred lines varied from 7.4 to 12.6 % (*Vasal, 2001*).

Table 2. Average values of 1000 seed weight (g) and dry matter content (%) in 15 inbred lines originated from local populations of Eastern Serbia

Inbred line	1000 seeds weight (g)				Dry matter content (%)			
	2003		2004		2003		2004	
	Mean	LSD	Mean	LSD	Mean	LSD	Mean	LSD
1	352.65	b	349.65	bc	10.19	lm	10.21	jklm
2	323.00	jk	321.05	klm	10.14	m	10.19	klm
3	313.67	no	319.00	klm	10.50	defg	10.55	cdef
4	311.03	o	317.31	mn	10.65	cd	10.42	efghi
5	331.64	gh	332.32	gh	10.86	ab	10.96	a
6	320.67	klm	322.33	jkl	10.29	ijklm	10.39	fghi
7	319.33	klm	325.63	ij	10.23	jklm	10.28	ijklm
8	331.05	gh	337.64	ef	10.20	jklm	10.28	ijklm
9	331.04	gh	336.67	ef	10.37	ghij	10.40	fghi
10	329.31	hi	334.66	fg	10.32	ijkl	10.57	cde
11	347.32	cd	365.04	a	10.49	defgh	10.68	c
12	339.05	e	344.31	d	10.65	cd	10.71	bc
13	318.67	lm	326.06	ij	10.15	m	10.21	jklm
14	340.01	e	346.33	cd	10.33	hijkl	10.42	efghi
15	339.00	e	344.65	d	10.35	ghijkl	10.36	ghijk

Note: Mean values with the same letter in LSD column are not significantly different according to Fisher's LSD test ($p < 0.01$)

Table 3. Average values of protein content and lysine content in 15 inbred lines originated from local populations of Eastern Serbia

Inbred line	Protein content (%)				Lysine content (%)			
	2003		2004		2003		2004	
	Mean	LSD	Mean	LSD	Mean	LSD	Mean	LSD
1	9.86	jkl	9.88	ijk	3.90	a	3.90	a
2	9.75	m	9.73	m	2.78	j	2.72	k
3	10.00	efg	9.95	ghi	3.79	b	3.75	bc
4	10.84	a	10.78	a	1.58	r	1.53	s
5	10.01	efg	8.99	fg	3.26	i	3.22	i
6	9.33	p	9.31	p	3.43	ef	3.41	fg
7	10.12	cd	10.07	de	2.59	mn	2.52	o
8	9.98	gh	9.96	gh	2.30	p	2.28	p
9	9.90	hij	9.87	ijk	3.35	h	3.35	gh
10	10.31	b	10.28	b	2.70	kl	2.63	lm
11	9.64	n	9.62	n	3.50	d	3.47	de
12	9.53	o	9.51	o	3.78	b	3.70	c
13	9.81	klm	9.78	lm	3.25	i	3.22	i
14	10.12	cd	10.07	def	2.58	mn	2.53	no
15	10.17	c	10.14	cd	2.33	p	2.30	p

Note: Mean values with the same letter in LSD column are not significantly different according to Fisher's LSD test ($p < 0.01$)

In this study, the protein content is derived from 9.31(line No. 6 in 2003) to 10.84 % (line No. 4 in 2003; Tab. 3). There was high variability of the testing material in protein content, and differences between lines were statistically significant. The

protein content is characteristic strongly influenced by the genetic factors; however, the crude protein content is not necessarily an indication of the quality. The quality of plant proteins depends on the amount of the essential amino acids and their digestibility *(Gasic, 1992)*. Maize, according to the content of essential amino acids, is not one of quality nutrients. Lysine is not contained to a greater extent in the standard types of maize seed, which reduces their nutritional value. *Bewley and Black (1985)* reported the results of lysine content in maize normal type of 1.6 %, and in *opaque-2* type 3.7 %. In this paper, in both years, eight lines (1, 3, 5, 6, 9, 11, 12 and 13) obtained lysine content over 3 %; which is considered as a high content of lysine in the "regular" types of corn. This feature had high variability among investigated lines (Table 3). The 1000 seed-grain mass was in negative correlation with total protein, and in positive correlation with lysine. But, these correlations were small and not statistically significant. At the same time correlation between the protein content and lysine content was significantly negative (Table 4).

Table 4. Correlation coefficients between investigated features in 2003 and 2004.

	Protein content		Lysine content	
Year	2003	2004	2003	2004
1000 seed mass	-0.30	-0.16	0.35	0.28
Dry matter content	0.2	-0.44	0.07	0.25
Protein content	-	-	-0.75	-0.67

Three lines (1, 3 and 9) had a high protein content as well as lysine in both years. Also, inbred lines 5 and 13, have demonstrated this just in one year. Lines in both of cases were marked with the red dots on the charts (Figure 1).

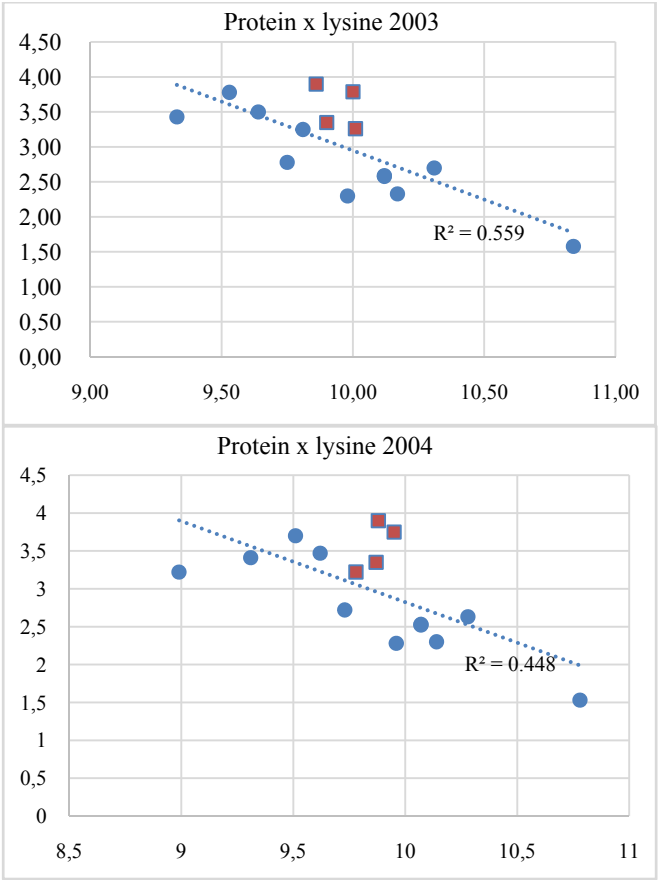

Fig. 1. Regression analyssis of correlations between proteine and lysine content in 2003 and 2004.

CONCLUSION

By surveying 15 inbred lines of maize, we can conclude that there is high variability within the investigated material. The results indicated that the local maize landraces can be a significant source of beneficial genes to obtain better quality hybrids. Several lines could be a good material for obtaining maize hybrids with high quality grain. Eight lines had lysine content higher than 3 % (1, 3, 5, 6, 9, 11, 12, 13). At the same time, five inbred lines (1, 3, 5, 9 and 13) had relatively high total protein content. Inbred line No. 1 had the highest lysine content in this research (3.90 %). Further research should focus attention on improving these 8 lines, testing them in hybrid combinations, examination of heterotic potential, etc.

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